

As described above, Fig. 1 illustrates a single-channel wavelength converter 100, Fig. 2 illustrates an output-stabilized controlled wavelength converter 200, and Fig. 4 illustrates a multi-channel wavelength converter 400. Nevertheless, it should be recognized that elements and features described above with regard to each of these embodiments can be combined with those described above with regard to the other embodiments or with any other elements and features known in the art, in any suitable manner and in any suitable combination, to give rise to still further embodiments of the invention.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. Other embodiments of the invention will be apparent to those skilled in the art as a result of consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with the true scope and spirit of the invention being indicated by the following claims.

WHAT IS CLAIMED IS:

1. An optical wavelength converter, comprising:
 - an optical sum frequency generator;
 - an optical difference frequency generator;
 - a continuous-wave optical beam source;
 - a splitter having an input coupled to a converter input and having a first splitter output and a second splitter output;
 - a first combiner having a first input coupled to the first splitter output, a second input coupled to an output of the continuous-wave optical beam source, and an output coupled to an input of the optical sum frequency generator; and
 - a second combiner having a first input coupled to an output of the optical sum frequency generator, a second input coupled to the second splitter output, and an output coupled to the input of the optical difference generator.
2. The optical wavelength converter claimed in claim 1, wherein:
 - the optical sum frequency generator comprises a three-wave mixing periodically-poled crystal; and
 - the optical difference frequency generator comprises a three-wave mixing periodically-poled crystal.
3. The optical wavelength converter claimed in claim 1, wherein the crystal of the optical sum frequency generator is poled in accordance with a poling function that includes harmonics of at least one predetermined poling frequency.
4. The optical wavelength converter claimed in claim 1, wherein the first combiner is integrally formed in a crystal with the optical sum frequency generator.
5. The optical wavelength converter claimed in claim 1, further comprising a depolarizer coupled between the converter input and the splitter.
6. The optical wavelength converter claimed in claim 1, wherein the optical beam

source is a continuous-wave pump laser.

7. The optical wavelength converter claimed in claim 6, wherein the laser is a single-frequency laser diode.

8. The optical wavelength converter claimed in claim 6, wherein the laser is a diffraction feedback laser diode.

9. The optical wavelength converter claimed in claim 6, wherein the laser is tunable.

10. The optical wavelength converter claimed in claim 1, wherein the second combiner is integrally formed in a crystal with the optical difference frequency generator.

11. The optical wavelength converter claimed in claim 10, wherein the second combiner comprises two waveguides having outputs coupled together, and at least one of the two waveguides is adiabatically tapered to match modes propagating in one of the two waveguides to modes propagating in the other of the two waveguides.

12. The optical wavelength converter claimed in claim 1, wherein the first combiner is integrally formed in a crystal with the optical sum frequency generator.

13. The optical wavelength converter claimed in claim 12, wherein the first combiner comprises two waveguides having outputs coupled together, and at least one of the two waveguides is adiabatically tapered to match modes propagating in one of the two waveguides to modes propagating in the other of the two waveguides.

14. The optical wavelength converter claimed in claim 1, wherein the splitter produces two output signals having linear, orthogonal polarizations.

15. The optical wavelength converter claimed in claim 14, wherein:
polarization-maintaining single-mode fiber couples the first input of the first combiner to the first splitter output; and
polarization-maintaining single-mode fiber couples the second input of the first combiner to the output of the continuous-wave optical beam source.
16. The optical wavelength converter claimed in claim 15, further comprising a polarization rotator coupling the second splitter output to the second input of the second combiner.
17. The optical wavelength converter claimed in claim 1, further comprising a high-pass filter coupling the output of the optical sum frequency generator to the first input of the second combiner, the high-pass filter having a cutoff frequency of approximately the sum of a frequency of the optical beam source and a frequency of a signal received at the converter input.
18. The optical wavelength converter claimed in claim 1, further comprising a bandpass filter coupling the output of the optical difference frequency generator to the converter output, the bandpass filter having a passband centered at approximately the frequency of the optical beam source.
19. The optical wavelength converter claimed in claim 1, further comprising amplitude control circuitry including a controller coupled in feedback relation in a signal path of the optical wavelength converter.
20. The optical wavelength converter claimed in claim 19, further comprising an amplifier coupling the converter input to the input of the splitter, wherein the controller has an input coupled to an output of the amplifier and a first output coupled to an input of the amplifier to provide feedback-controlled amplitude adjustment of the amplifier.

21. The optical wavelength converter claimed in claim 20, wherein the controller has a second output coupled to an input of the optical beam source to provide feedback-controlled amplitude adjustment of the optical beam source when adjustment of the amplifier is insufficient to achieve stability.

22. The optical wavelength converter claimed in claim 19, wherein the controller has an input coupled to an output of the difference frequency generator to provide feedback-controlled amplitude adjustment of the amplifier.

23. The optical wavelength converter claimed in claim 22, wherein the controller has a second output coupled to an input of the optical beam source to provide feedback-controlled amplitude adjustment of the optical beam source when adjustment of the amplifier is insufficient to achieve stability.

24. The optical wavelength converter claimed in claim 19, further comprising an amplifier coupling the converter input to the input of the splitter, wherein the controller has an input coupled to an output of the optical beam source and a first output coupled to a gain input of the amplifier to provide feedback-controlled amplitude adjustment of the amplifier.

25. The optical wavelength converter claimed in claim 24, wherein the controller has a second output coupled to an input of the optical beam source to provide feedback-controlled amplitude adjustment of the optical beam source when adjustment of the amplifier is insufficient to achieve stability.

26. An optical wavelength converter, comprising:
an optical beam source means for producing a continuous-wave beam;
splitter means for splitting a converter input signal beam carrying a data signal into first and second split beams;

sum frequency generator means for producing a sum signal having a frequency equal to a sum of a frequency of the first split beam and a frequency of the continuous-wave beam; and

difference frequency generator means for producing a difference signal having a frequency equal to a difference between a frequency of the sum signal and a frequency of the second split beam.

27. The optical wavelength converter claimed in claim 23, wherein:

the sum frequency generator means comprises a three-wave mixing periodically-poled crystal; and

the difference frequency generator means comprises a three-wave mixing periodically-poled crystal.

28. The optical wavelength converter claimed in claim 26, wherein the crystal of the sum frequency generator is poled in accordance with a poling function that includes harmonics of at least one predetermined poling frequency.

29. The optical wavelength converter claimed in claim 26, further comprising high-pass filter means for filtering the sum signal and providing a filtered sum signal to the difference frequency generator means.

30. The optical wavelength converter claimed in claim 26, further comprising bandpass filter means for filtering the difference signal and providing a filtered difference signal at a converter output.

31. An optical wavelength converter, comprising:
a plurality of optical sum frequency generators integrally formed with each other in a crystal;
a plurality of optical difference frequency generators integrally formed with each other in a crystal;

a plurality of continuous-wave optical beam sources;

a plurality of splitters, each having an input coupled to one of a plurality of converter inputs and having a first splitter output and a second splitter output;

a plurality of first combiners, each having a first input coupled to a corresponding one of the first splitter outputs, a second input coupled to an output of a corresponding one of the continuous-wave optical beam sources, and an output coupled to an input of a corresponding one of the optical sum frequency generators;

a plurality of second combiners, each having a first input coupled to an output of a corresponding one of the optical sum frequency generators, a second input coupled to a corresponding one of the second splitter outputs, and an output coupled to an input of a corresponding one of the optical difference generators; and

a multiplexer having a plurality of inputs, each coupled to an output of a corresponding one of the difference frequency generators, and having a converter output.

32. The optical wavelength converter claimed in claim 31, wherein:

the optical sum frequency generator comprises a three-wave mixing periodically-poled crystal; and

the optical difference frequency generator comprises a three-wave mixing periodically-poled crystal.

33. The optical wavelength converter claimed in claim 31, wherein each of the first combiners is integrally formed in the crystal with each of the optical sum frequency generators.

34. The optical wavelength converter claimed in claim 31, wherein each of the second combiners is integrally formed in the crystal with each of the optical difference frequency generators.

35. A method for converting a frequency of an optical input beam carrying a

communications signal, comprising:

receiving the optical input beam at a converter input;
producing a continuous-wave beam;
splitting the optical input beam into first and second split beams;
producing a sum signal having a frequency equal to a sum of a frequency of the first split beam and a frequency of the continuous-wave beam;
producing a difference signal having a frequency equal to a difference between a frequency of the sum signal and a frequency of the second split beam; and
outputting the difference signal at a converter output;
whereby the signal output at the converter output represents a modulation of the continuous-wave beam with the communications signal.

36. The method claimed in claim 35, further comprising the step of rotating a polarization of the second split beam.

37. The method claimed in claim 35, further comprising the step of high-pass filtering the sum signal at a cutoff frequency of approximately the sum of a frequency of the optical input beam and a frequency of the continuous-wave beam.

38. The method claimed in claim 35, further comprising the step of bandpass-filtering the difference signal at a passband frequency centered at approximately a frequency of the continuous-wave beam.

39. The method claimed in claim 35, further comprising the step of stabilizing an amplitude of a signal responsive to one of said optical input beam and said continuous-wave beam in response to a feedback signal.

40. The method claimed in claim 35, further comprising the step of depolarizing the optical input beam before the splitting step.